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Title: Assessment of Radiation Background Variation for Moving Detection Systems

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Assessment of Radiation Background Variation for Moving Detection Systems

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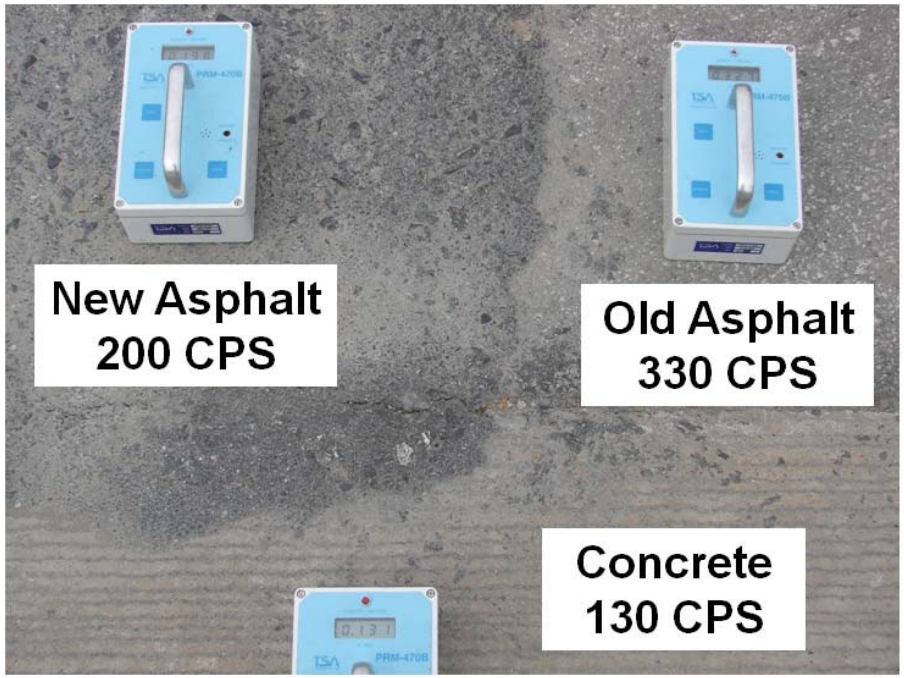
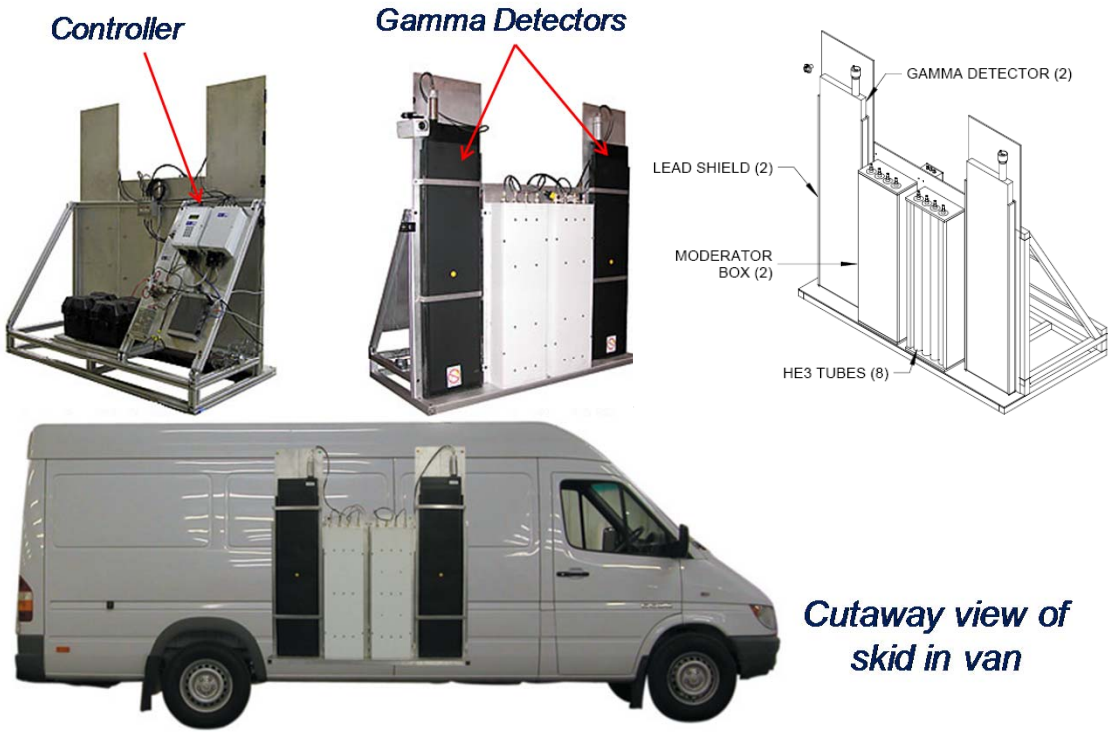
Introduction

- Radiation backgrounds fluctuate across very short distances
- Factors include geology, soil composition, altitude, building structures, topography, and other manmade structures
- Asphalt and concrete can vary significantly over short distances (Photo credit: Ian Gross, ORNL)



Instrument Description (MD-134)

- Originally designed to be used in stationary mode as a temporary portal
- Other portal side was designed to be a second van or skid
- Two PVT scintillator paddles (12” x 48” x 2”)
- Eight 2-in.-diameter ^{3}He tubes (poly moderated)



Cutaway view of skid in van

Experimental Setup

- Modifications to the existing system were needed for in-motion testing
- LANL developed an embedded web controller (EWC) for independent automated data collection
  - Incorporated time, location, and velocity using GPS
  - Operator analysis panel
  - Independent of standard COTS data collection for comparison

Background Variation Measurements

- Driveabouts: LANL term for controlled and documented, in-motion data collections
- Variety of terrains to be studied:
  - No test sources
  - Urban, suburban, and rural roadways
  - Parking lots
  - Different structures (composition, height, length, distance from the roadway, etc.)

Coronado Shopping Center

- Located in Albuquerque, NM
- Counts per second, with the gamma detectors summed

< 3K cps

3K – 4K cps

4K – 4.5K cps

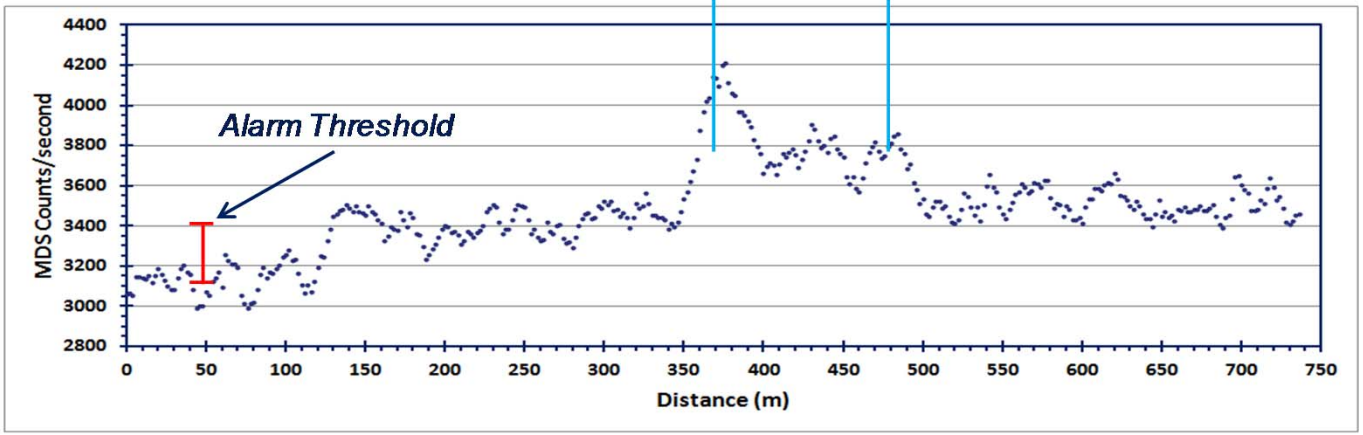
> 4.5K cps

Downtown Albuquerque

- Examples of large background variation
- Concrete and marble buildings affect background
- Vertical buildings can have larger background signal than horizontal
- Some geological features (granite rock cut) can have large effects
  - Triple the background of surrounding areas (8000 cps)

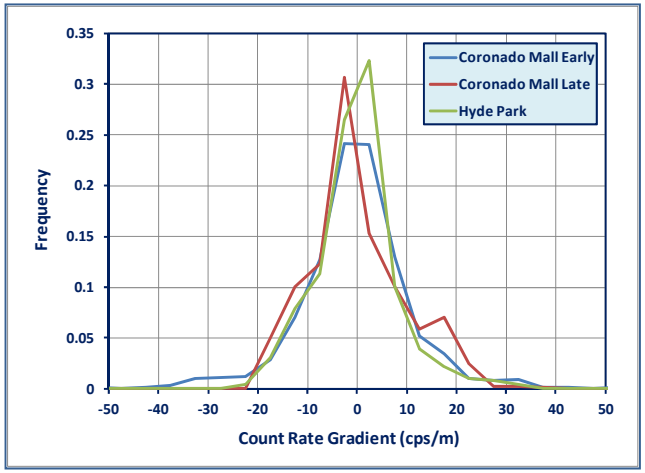
LANL Driveabouts

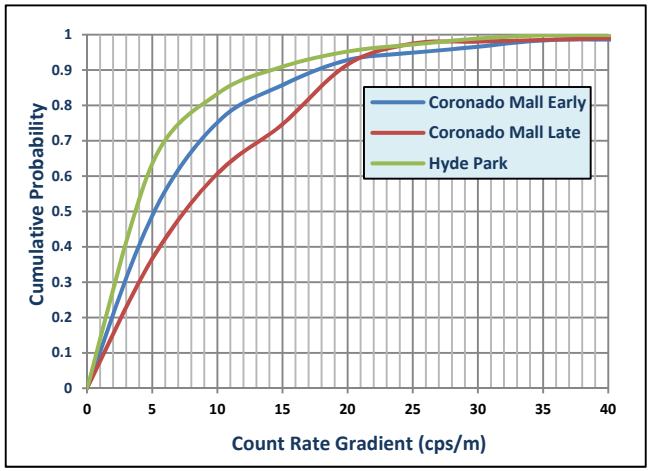
- Detectors facing south side of the road
- Variations exceed alarm threshold at many points
- Golf course clubhouse has large increase in background
- Nsigma of 4.5 was used (standard setting)



Background Results and Analysis

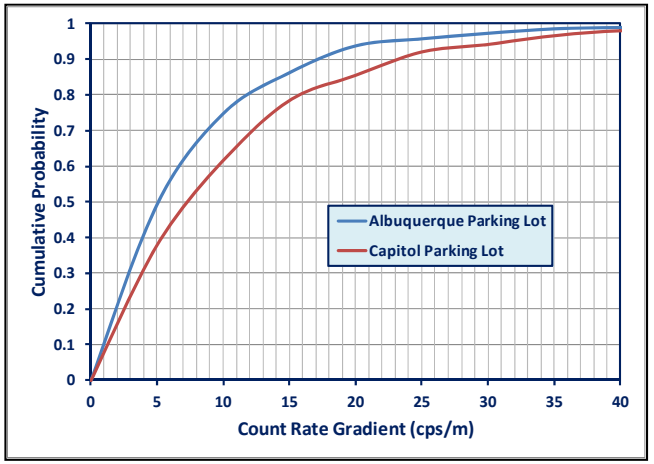
- Data averaged over 5 s
- Distribution of the gradients analyzed
  - How rapidly the count varies with distance (cps/m)
- Cumulative probability of the gradients calculated

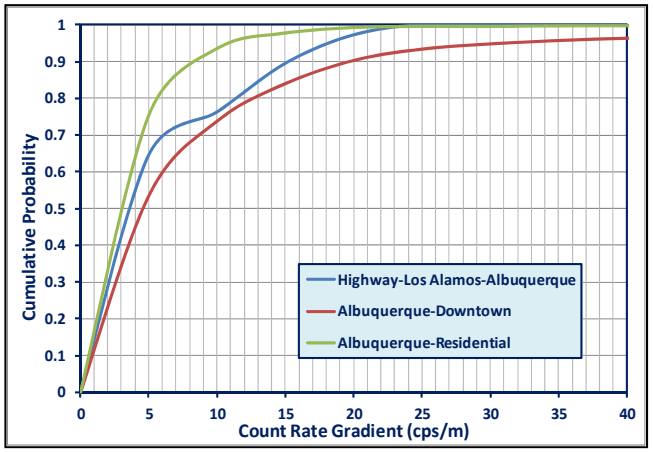




Additional Cumulative Probabilities

- Parking lots can differ, as well
  - Asphalt composition
  - Car occupancy
- Residential, highway, and downtown data had significantly different gradient profiles





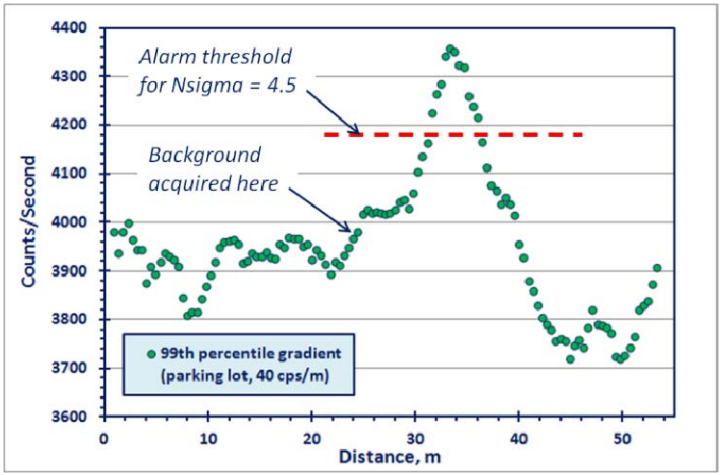
Parking Lots, Roads, and Cities

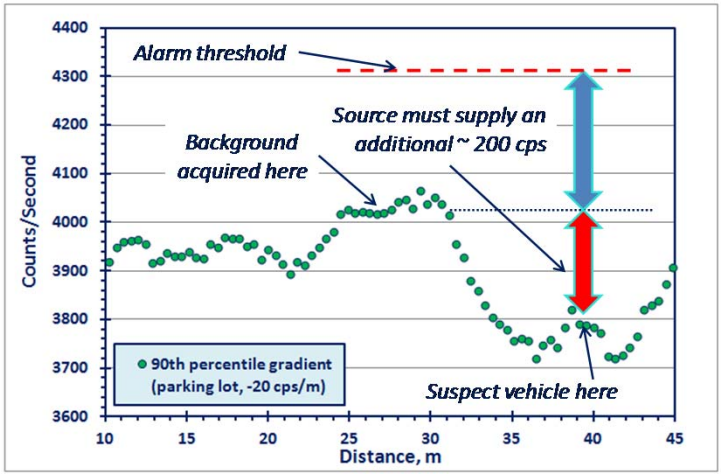
- Downtown (business) areas had larger gradients than residential
- Parking lots could have large variations (car occupancy, distance to buildings, aggregate materials)
- Biggest single variation was in downtown Albuquerque
- 99th-percentile gradients cause the most issues with detection
- Other locations could have lower average background
  - Variations would be expected to be correspondingly smaller
  - Acquiring more data in other locales would help

	50th Percentile, cps/m	90th Percentile, cps/m	95th Percentile, cps/m	99th Percentile, cps/m
Coronado Mall Early	5.2	17.8	28	53
Coronado Mall Late	7.7	19.5	24	40
Hyde Park	3.7	14.1	19	30
Capitol Parking Lot	7.5	23.2	32	58
Albuquerque Parking Lot	5.0	17.4	23	43
Highway Los Alamos to Albuquerque	3.8	15.3	19	25
Albuquerque-Residential	3.3	9.0	12	20
Albuquerque-Downtown	4.7	19.5	30	80
Average	5.2	18.0	25.4	48.2

Background Variation Effects

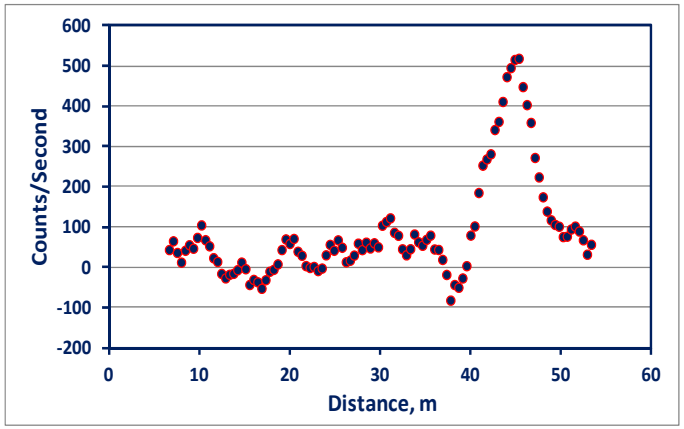
- Two major effects in scan mode in comparison with fixed portals
  - Positive gradient:
    - Background is acquired
    - MDS moves, and background increases
    - Can cause false alarm
  - Negative gradient:
    - Background is acquired
    - MDS moves, and background decreases
    - Causes increased minimum detectable quantity (MDQ)

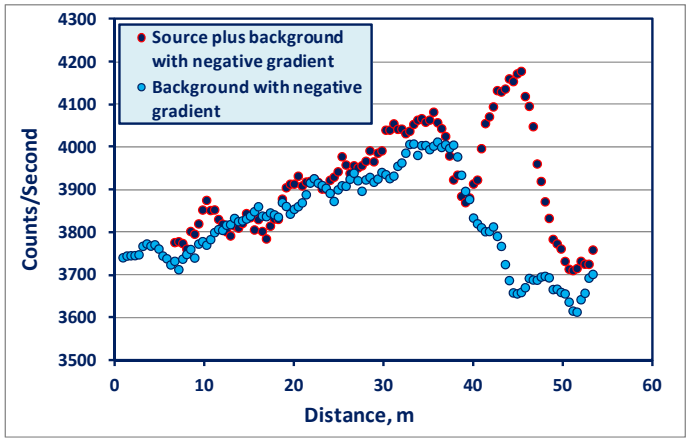




Negative Gradient Effect Example

- Upper graph: Signature of background and uranium source
- Lower graph: Signature of engineered background with a negative gradient and uranium source
- If the background was taken at the peak (4070 cps) with 4.5 Nsigma, the source was not detected





Conclusions

- Positive and negative gradients can greatly reduce the detection sensitivity of an MDS
  - Negative gradients create opportunities for false negatives (nondetection)
  - Positive gradients create a potentially unacceptable FAR (above 1%)
- Location of use for mobile detection is important to understand
- Spectroscopic systems provide more information for screening out false alarms and may be preferred for mobile use
- Mobile monitor testing at LANL accounts for expected variations in the background

Acknowledgments

- This work was funded under the US Department of Energy's Nuclear Smuggling, Detection, and Deterrence (NSDD, formerly the Second Line of Defense) Program. The test was undertaken at the request of the NSDD Program to understand the issues and capabilities related to partner countries' use of the MD-134 while in motion.
- This work was conducted by LANL personnel in the Nuclear Engineering and Nonproliferation Division (NEN), particularly the NEN-3 and NEN-1 groups.
- The related paper to this work is LA-UR-15-25051.